

AN APPARATUS FOR MEASURING DISTANCE

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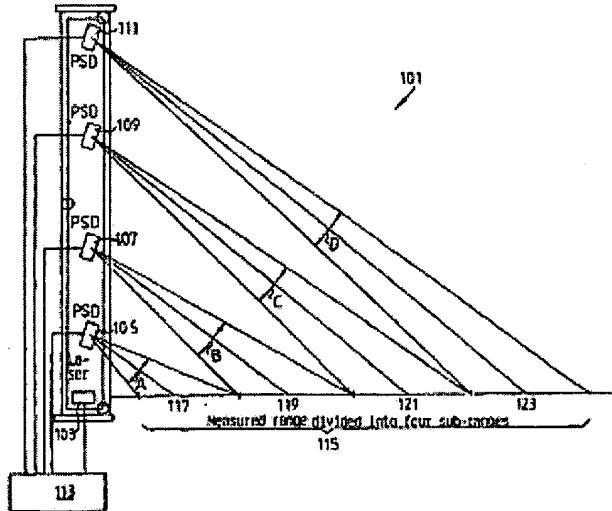
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 US4864147
 US4349274
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Abstract of WO0050842

In a triangulation distance measuring system several position sensing means are provided in order to sense a certain predetermined part of the total measuring range each. Hereby the resolution can be increased without increasing the cost due to more expensive detector elements in the form of for example PSD-elements or CCD-arrays and more expensive lens arrangements having high requirements on accuracy. Further more an almost arbitrary resolution can be obtained by means of providing more detector elements for a given measured range.



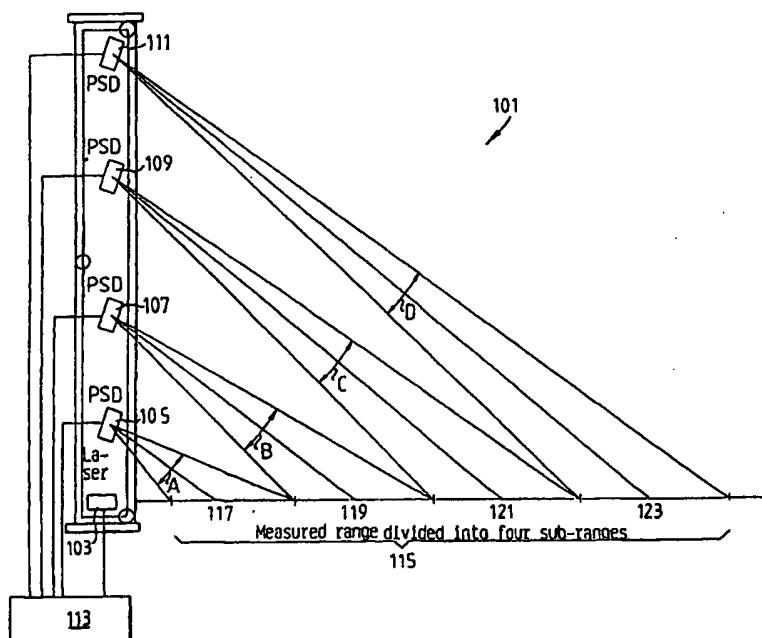
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(54) Title: AN APPARATUS FOR MEASURING DISTANCE



(57) Abstract

In a triangulation distance measuring system several position sensing means are provided in order to sense a certain predetermined part of the total measuring range each. Hereby the resolution can be increased without increasing the cost due to more expensive detector elements in the form of for example PSD-elements or CCD-arrays and more expensive lens arrangements having high requirements on accuracy. Further more an almost arbitrary resolution can be obtained by means of providing more detector elements for a given measured range.

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An apparatus for measuring distance.
TECHNICAL FIELD

The present invention relates to a device for distance measurement, and in particular the invention relates to a system for distance measurement using triangulation.

BACKGROUND OF THE INVENTION AND PRIOR ART

When measuring a distance different methods can be used. For example triangulation can be used. In triangulation a beam, for example a laser beam, is transmitted and reflected by an object to which one wants to measure the distance to. By means of in suitable way measuring the angle at which the reflected beam is reflected in a detector located at distance from the beam source the distance to the object can be calculated.

When detecting or deriving the angle, for example a PSD-element or a CCD-array can be used. For example, the reflected beam can be transmitted through an arrangement of lenses at the detector so that the beam reaches the PSD-element or CCD-array at different locations in response to the distance to the object or thing reflecting the beam.

Conventional methods for measuring distances using triangulation are for example described in US 5,373,344 which discloses a distance measuring device using infrared beams.

A problem with conventional triangulation systems is that the resolution is relatively low. This in term mainly depends on that the number of discrete points in conventional PSD-elements and CCD-arrays are relatively low. A straight forward solution to this problem is of course to have PSD-elements or CCD-arrays manufactured having considerably more light sensitive points. This will however become expensive. Furthermore, new problems occur since the lens arrangement used for directing the reflected beam towards the PSD-element or CCD-array must be given an accuracy corresponding to the higher resolution in the

array. This fine adjustment and fine machining of the optical lens system will in itself be expensive.

SUMMARY

It is an object of the present invention to overcome the problems described above and in particular to obtain a triangulation distance measuring system which is inexpensive to manufacture and which at the same time provides a high resolution.

This object and others are obtained by a triangulation distance measuring system having a multitude of position sensing means abided to sense a certain predetermined part of the total measured range each. A central unit puts together the measured signals from the different measured ranges into a total measured signal for the entire measured range.

Hereby, the resolution can be increased without increasing a cost due to more expensive detector elements in the form of example PSD-elements or CCD-arrays and more expensive lens arrangement having high requirement regarding accuracy. Furthermore, an almost arbitrary resolution can be obtained by means of providing more detector elements for a given measured range.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in more detail with reference to the accompanying drawings, in which:

- Fig. 1 shows a triangulation distance measuring system having a multitude of detector elements.
- Fig. 2 illustrates the principle of a one-dimensional PSD-element.
- Fig. 3a and 3b shows signal forms at a detector and in a modulated laser, respectively.

DESCRIPTION OF PREFERRED EMBODIMENTS

In fig. 1 a triangulation distance measuring system 101 having a multitude of detector elements is shown. The system comprises a light omitting device 103, for example a laser, at least two light detecting elements, and in this example four elements 105, 107, 109 and 111, for example PSD-elements and a control- and calculation unit 113, for example a microprocessor connected to a memory.

The detector elements 105, 107, 109 and 111 are provided to detect light along a given measured range 115. The detector elements are preferably provided to detect light in a given sub-range of the total measured range. This can be obtained by means of providing a conventional lens system (not shown) for each detector element so that the first element 105 measures a first sub-range 117, a second element 107 measures a second sub-range 119, a third detector element 109 measures a third sub-range 121, etc.

In a preferred embodiment the aperture angles and the focal distance for the different detector elements are different. In particular the aperture angles are chosen so that the different sub-ranges which each detector element measures are essentially equally long. Thus, in an arrangement as the one shown in fig. 1, where the detectors are arranged in a row perpendicular to the transmitted beam, the angle A will be larger than the angle B which in turn is larger than the angle C and which in turn is larger than the angle D. Further more, it is can be advantageous to let the different sub-ranges lightly overlap so that one ensures that "blind" spots in the measured range is avoided.

In Fig. 2 a principle construction of a one-dimensional PSD-element is shown. A PSD-element is a silicon plate 201 which outputs a sum of currents ($X_1 + X_2$). This sum of currents is essentially proportional to the received amount of light and the sub-currents X_1 and X_2 are determined by where on the PSD-

elements a incoming light beam is received. Further more, there is a reference electrode L provided on the PSD-element.

By using the formula :

$$(X_2 - X_1) / (X_1 + X_2)$$

the co-ordinate on the PSD-element can be derived regardless of the light intensity.

A remaining problem is however that co-ordinate given by the PSD-element is not independent of incoming scattered light. Therefore, in a preferred embodiment, the laser light as shown in Fig. 3b is modulated, i.e. during a first half period a laser beam is transmitted and during a second half period no laser beam is transmitted. By means of then measuring the response from the PSD-element two times per each full period the contribution from scattered light can be eliminated by means of forming the difference:

$$X_{1_{\text{pos}}} - X_{1_{\text{neg}}}$$

I.e., first laser light + scattered light is measured and then only scattered is measured and thereupon the difference between the two measured values is formed.

Hereby only the useful signal filtrated from noise which otherwise will corrupt the measurement is obtained. In order for the method to work properly it is required that measurement of the response from detector element is measured synchronously with the emitted modulated laser pulses. This synchronisation is provided by means of control of the control- and calculation unit 113.

The controller unit 113 puts together the information from the different detectors and outputs a measure value which

corresponds to both which detector that senses the laser beam and also which measured value this detector is outputting. In the case when several detectors senses a reflected laser beam at the same time, i.e. in the case when the different sub-ranges of the detectors overlap, the controller unit 113 can chose either of the two detectors, for example the one measuring the range beam further away, or the control unit can be arrange to output a mean value for the two derived measured values.

In yet another preferred embodiment curve fitting using a polynom in the controller unit 113 is used to calibrate and make linear optical and other imperfections in the measuring system. Thus, the measuring system is calibrated with a number of measured values and a polynom of suitable size is used to model data between the calibration points. Curve fitting is preferably formed using a special polynom for each detector by means of calibration in a suitable number of points. Curve fitting compensates for geometric, optical and electrical non-linearities and for other possible deviations. For example, a polynom of size 5 or 6 can be used to provide a suitable curve fitting.

Furthermore, the mechanical structure used to keep the different parts of the system in place can be formed to minimise the risk for measurement errors resulting from that the geometry in the system is changed. Thus, in preferred embodiment, an outer tube profile is provided, in which two through bolts are located between two end pieces. A temperature stable plate, for example invar, is mounted on the bolts.

The plate in turn carries part essential for the accuracy of the measurement, such as light source and light detectors. By means of using a plate fasten in three points and which freely runs on two pre-loaded axes which are located between the ends of the measuring devices which are places apart by the housing of the measuring device, for example formed as a round or polygonal

tube the base of the measuring device will not be effected by variances in temperature, pressure or mechanical forces. Thus, the arrangement becomes a temperature stable and robust unit which fulfills the high requirement which today are common in industries.

By using the triangulation measuring system as described herein the resolution can be increased without increasing the cost due to or expensing detector elements in the form of for example PSD-element or CCD-arrays and more expensive than lens arrangement having high requirements on accuracy. Further more, an almost arbitrary resolution can be obtained by means of locating more detector elements in a given measured range. The system can further more easily be made in sensitive form changed in temperature and scattered light.

CLAIMS

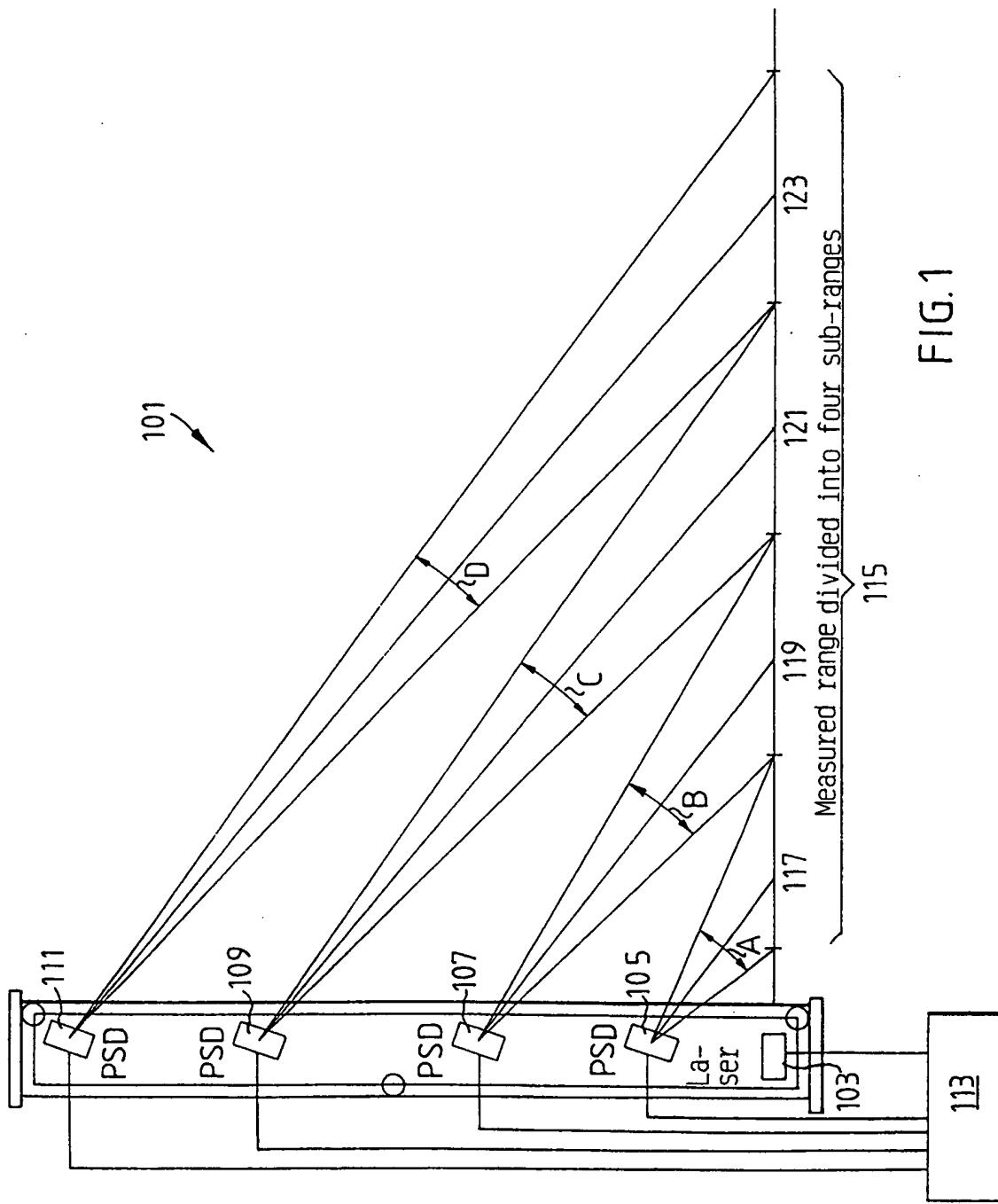
1. Triangulation measuring system comprising a light source (103), which transmits a light beam, a first light sensitive detector (105) provided to sense light which is reflected by an object which is present within a range which can be detected by the detector (105), **characterised in that** a second light sensitive detector (107, 109, 111) is provided to sense reflected light from a range, which, at least partly, extends outside the range measured by the first detector.
2. A system according to claim 1, **characterised in that** a light source is a modulated laser provided to interchangeably emit periods of laser light and interchangeably periods without laser light.
3. A system according to claim 1 or 2, **characterised by** a controller- and calculation unit (113) provided to put together measured values from the different detectors into one output signal corresponding to the currently measured distance.
4. A system according to claim 3, **characterised in that** the unit (113) is arranged to be calibrated using a polynom for each detector in order to make the measured range of the detectors linear.
5. A system according to claim 4, **characterised in that** the polynom is a polynom of degree 3 - 10, for example 5 or 6.
6. A system according to claim 3, 4 or 5, when dependent on claim 2, **characterised in that** the unit (113) is arranged to use the difference between the detector output signals when the modulated laser emits lights and when it does not emit lights as input signal from the detectors in order to avoid interference from scattered light.

7. A system according to any of claims 1 - 6, **characterised in** that the light source and that the detectors are mounted on a common temperature stable plate.

8. A system according to claim 7, **characterised in** that the plate is made of invar.

9. A system according to claim 7 or 8, **characterised in** that the plate is fixed at three points and freely runs on two pre-loaded axis located between the ends of the measuring devices which are spaced apart by the housing of the measuring devices, for example formed as a round or polygonal tube.

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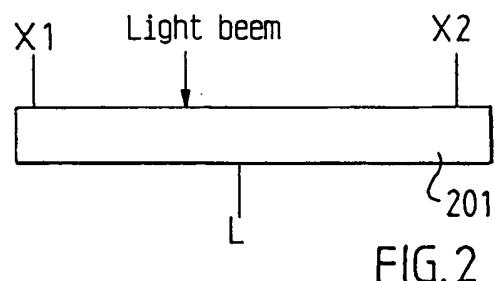
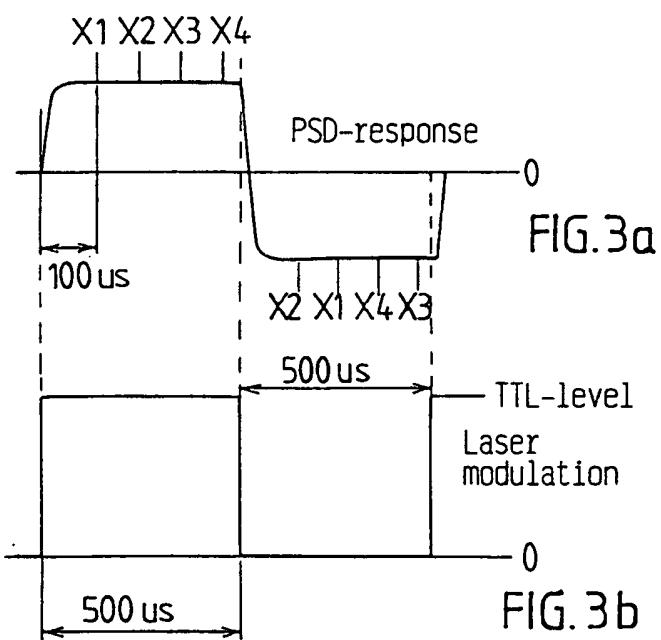


FIG. 2



INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 00/00374

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: G01B 11/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: G01B, G01S

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	US 5373344 A (S.KAKIUCHI), 13 December 1994 (13.12.94), column 1, line 36 - line 61, abstract --	1-9
A	US 4864147 A (M.IKARI ET AL), 5 Sept 1989 (05.09.89), abstract --	1-9

Further documents are listed in the continuation of Box C.

See patent family annex.

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Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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